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(54) ARC PLASMA TORCH AND METHOD USING CONTACT STARTING.

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No further relevant document have been disclosed.

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Description

The present invention relates to arc plasma torches, and more particularly to a method and a mechanical/pneumatic arrangement for contact starting an arc in such torches.

There are three currently known methods to initiate a plasma arc discharge and start an arc plasma torch: high frequency or high voltage discharge, contact starting, and with an exploding wire technique. In each method, an arc is drawn between a cathode and an anode, and an ionizable gas is directed to flow around the arc, creating a plasma jet.

The oldest, and still most widely used method in the prior art is the high frequency discharge or high voltage spark discharge method. In either case, a high voltage breaks down the gap between a cathode and an anode, generating charge carriers which create the electric current path necessary to start the arc. An example of this method is disclosed in U.S. Pat. No. 3,641,308 to Couch Jr. et al. In that patent, a brief high voltage pulse is provided to the cathode which initiates an arc discharge across the gap from the cathode to a grounded workpiece.

Until recently, the high frequency method of arc starting was used exclusively for plasma torches. However, such an arc starting circuit produces significant amounts of electromagnetic interference in nearby electronic equipment, requiring either extensive shielding or remotely locating the electronics. Furthermore, the equipment required to generate the high frequency discharge tends to be quite expensive and has had a negative impact on the economic competitiveness of plasma cutting torches when compared with other cutting methods.

The second known starting method is contact starting. Although initially developed by Creare Inc. for the Air Force in the early 1960's, this method is just beginning to gain in popularity. Contact starting uses low electric currents, and eliminates the need for high frequency equipment along with the associated high cost and electromagnetic interference. The present invention relates to a novel variation in contact starting, as more fully discussed below, and shares in the known benefits of contact starting.

In all known torches which use contact starting, the cathode is manually placed into electrical connection with the workpiece, a current is passed from the cathode to the workpiece, and the arc is struck by manually backing the cathode away from the workpiece. In several prior art systems, the cathode is the electrode, and the nozzle through which the plasma jet passes serves as an electrical conductor connecting the electrode with the workpiece. In these systems, the nozzle is slidable with respect to the electrode, and is forced into contact with the electrode when it is pressed against the workpiece. Thus, the electrode, nozzle, and workpiece are all in electrical series connection when the current flow is initiated. When the electrode is manually backed away from the workpiece, the nozzle is allowed to separate from the electrode and return to its normal position.

These contact starting systems are disadvantageous since the nozzle is pressed against the workpiece. Since there is usually a brittle ceramic element at the end of the nozzle, such pressing risks damage to the nozzle. Also, it is difficult in practice to initiate a cut while at the same time attempting to press the nozzle down onto a workpiece. Another significant problem with this starting method is that nonconductive coatings such as paint makes electrical contact starting using the workpiece very difficult. As a result, most manufacturers today use a pilot arc circuit even when they have contact starting in order to cut through the paint layer.

The third known method of arc plasma torch starting is known as the "exploding wire" technique. An electrical conductor is extended from the cathode to the workpiece. The conductor vaporizes when the current is initiated, leaving the arc in its place. An obvious drawback to the exploding wire technique is, of course, that it is not practical for use in restartable plasma torches.

US-A-3,242,305 discloses an automatic starting plasma arc torch wherein an electrode moves away from a nozzle to draw an arc under the influence of water pressure, the water additionally acting to move the torch.

US-A-3,004,189 also discloses an automatic starting plasma arc torch wherein an electrode moves away from a nozzle to draw an arc. In this case the movement is caused by the action of a solenoid which acts to draw the electrode away from the nozzle.

It is therefore a principal object of the present invention to provide an arc plasma torch that can be started without high frequency discharge or high voltage spark discharge.

Another principal object of the present invention is to start arc plasma torches without electromagnetic interference in nearby electronics.

It is still another object to provide a torch which can be started away from the workpiece.

A further object is to provide a torch which may be easily restarted after shutdown.

It is still a further object to provide a torch which automatically draws an arc.

Yet a further object is to provide the torch which can be constructed relatively simply and economically, can be operated without expensive external electronics, and can be readily and easily repaired.

The present invention relates to an arc plasma torch and method for contact starting the torch in which a moveable cathode automatically separates from an anode in response to the buildup of gas pressure within the torch. Current flowing from the cathode to the anode before the separation creates a pilot arc across the gap as the cathode and anode separate.

When the pilot arc is drawn across the gap between the nozzle and elecrode, and the plasma jet is emitted from the nozzle, the torch is operating in the non-transferred pilot arc mode. It may continue to be used in this manner, shut down for later restarting by turning off the supply of current and gas, or the arc may be transferred to a workpiece.

The torch comprises a body having a plasma exit port at one end, an anode supported on the body, a cathode supported within the body, the anode and cathode being mounted for a mutual linear recriprocating movement along a first direction, means mounted within the body for resiliently urging the cathode along the first direction into electrical contact with the anode and thereby closing the exit port and means for causing an electrical current to flow between the cathode and anode.

In the apparatus of the invention means are provided for directing a gas to flow within the torch to separate the anode from the cathode forcibly, the directing means including a chamber located within the body between the cathode and the anode that is closed to the exterior of said torch by the cathode closing the exit port when the cathode and anode are placed into contact; a surface is provided transverse to the first direction and coupled to the moveable one of the cathode and anode and against which the gas acts to separate the anode and cathode whereby an electrical arc is generated between the cathode and anode and whereby the exit port is opened.

The present invention includes a hand-held torch in which the electrical current flow followed by the gas flow are both automatically initiated, in the proper sequence, by depressing a single start button. In this hand-held embodiment, the start button urges a plunger into electrical contact with a check ball to close a starting circuit. The power supply detects this closure of the starting circuit and causes electrical current to flow from the electrode (cathode) into the nozzle (anode). By depressing the start button further, the check ball is driven away from its seat permittinggas to flow within the torch and into the plenum beneath the piston part, exerting a pressure against the spring and moving the electrode away from contact with the nozzle, drawing an arc and producing a plasma jet.

These and other features and objects of the present invention will be described in the following detailed description of the invention which should be read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view in vertical section of a preferred embodiment of an arc plasma torch using a contact starting system constructed in accordance with the present invention;

Fig. 2 is a view in vertical section of a preferred embodiment of a hand-held arc plasma torch using a contact starting system constructed in accordance with the present invention; and

Fig. 3 is a graph depicting time-dependent variations in gas pressure and electrode displacement of an arc plasma torch started in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, there is a plasma torch 10 having a generally cylindrical body 12, an electrode 14, and a nozzle 16 having a central orifice 18. A main current and gas tube 20, located at the top of the body 12, leads to an upper plenum 22 within connector block 24, then to a passage 26 within the body 12, next to an annular space 28 between the body 12 and a cap 30 attached to the body. The cap 30 is threaded onto the body 12 to facilitate replacement of internal parts. Gas inlet swirl holes 32 lead from the annular space 28 to a plasma chamber 34 between the body 12 and the nozzle 16. The swirl holes 32 are tangential to the chamber 34 so that gas flowing into the chamber will swirl around the electrode 14. A flow of an ionizable gas such as nitrogen is directed around and adjacent to the electrode 14 so that an arc plasma column is formed which is directed through the nozzle 16.

One end of a plunger wire 36 is attached to the connector block 24 and the other end to a plunger 38. The plunger 38 is urged into abutting contact with the electrode 14 by an electrode spring 40. As shown, the electrode spring 40 is in its fully extended position, and thus the plunger 38 forces the electrode 14 against a contact area 42 of the nozzle 16, blocking the nozzle orifice 18. A pilot arc return lead 44 passes within the body 12, connecting to a cap current ring 46.

Electrode 14 has a circumferential flange forming a piston part 48 fabricated to slidingly fit within a cylinder 50 formed in the bottom of the torch body 12.

The body 12 is fabricated from an electrically insulating material such as the high temperature plastic sold by I.E. DuPont de Nemours Co. under the trademark V spel. The electrode spring 40 is preferably fabricated from a metallic material such as stainless steel or beryllium copper All of the other foregoing components of the torch 10 are fabricated from electrically conducting structural materials.

Generally stated, to start the arc plasma torch of the present invention there must be an electrical current flow followed by ionizable gas flow. After a power supply (not shown), which is connected to the remote end of the main current and gas tube 20, is turned on, current flows through the tube 20, the connector block 24, the plunger wire 36, the plunger 38, and into the electrode 14. As shown, the electrode 14 is forced against the contact area 42 of the nozzle 16. This is the normal position for the electrode during the current flow step of starting the torch 10. Thus, current will flow from the electrode 14 through the nozzle 16, into the cap 30, current ring 46, and pilot arc return lead 44. The pilot arc return lead 44 is also connected to the remote power supply. As the current is simply flowing through the torch 10, and not across an arc, this is known as the "dead short" mode of operation.

After current is flowing in the dead short mode, a remote gas valve (not shown), connecting the main current and gas tube 20 to a pressurized external supply of a gas 51, is opened and gas is allowed to flow into the torch through the tube 20. The gas flow generally follows arrows 52, filling the upper plenum 22, flowing through the passage 26, the annular space 28, the swirl holes 32, and filling the plasma chamber 34. In an alternate embodiment, some of the gas flow may be bypassed through cooling holes 54, shown in phantom in Fig. 1, to cool the external surface of the nozzle 16.

As the gas flows into the torch 10, the gas pressure within the plasma chamber 34 increases, exerting a force on the underside of the piston part 48 of the electrode 14 which opposes the force exerted upon the electrode by the electrode spring 40. When the gas pressure becomes high enough, the force on the piston part 48 counteracts and overcomes the force of the spring 40 and the electrode 14 is driven upward within the cylinder 50, opening the orifice 18, breaking electrical contact at area 42 and coming to rest against a bottom end 56 of the cylinder. As a result of the break in electrical contact between the electrode 14 and nozzle 16, an electric arc is generated between the electrode (which serves as the cathode) and the nozzle (which serves as the anode). The arc between the electrode 14 and nozzle 16 is known as the pilot arc. The gas flowing around the pilot arc and through the nozzle orifice 18 forms a plasma jet.

When the arc is formed within the torch and the plasma jet is emitted from the nozzle orifice 18, the torch is operating in what is known as the nontransferred "pilot arc mode". The torch may be used in this mode, transferred to operate upon a workpiece, or may be shut down for later restarting. To shut the torch down, the electrical current flow from the power supply is interrupted, shutting down the pilot arc between the electrode 14 and nozzle 18. Next, the remote gas valve is closed, stopping gas flow into the torch, and reducing the gauge pressure within the plasma chamber 34 to zero. Without the counteracting gas pressure, the electrode spring 40 urges the electrode 14 back into its normally closed position, resting against the contact area 42.

Of course, under normal circumstances, rather than shutting the torch down, it is usually operated in the "transferred mode". The torch, operating in the pilot arc mode, is brought near a workpiece (not shown) held at the same electrical potential as the nozzle. The plasma gas leaving the nozzle orifice 18 ionizes the gap between the nozzle 16 and the workpiece creating a current path, and the arc transfers, extending from the electrode 14 to the workpiece. After the arc is transferred to the workpiece, the current flow in the pilot arc return lead 44 may be interrupted by a switch or relay (not shown), stopping all current flow in the pilot arc circuit.

Referring now to FIG. 2, a hand-held plasma torch 60 operates in a manner similar to that of torch 10. Corresponding components in the torches 60 and 10 are identified herein with the same reference numerals, but with primes added for components of the torch 60 which have a different configuration from those in the torch 10. A generally cylindrical torch body 12' is located by a cap current ring 46' below a torch head 62. The torch body 12' corresponds to the lower portion of the body 12 in torch 10, while the torch head 62 together with a torch handle 64 correspond generally to the upper portion of the body 12. As in torch 10, the hand-held torch 60 includes the moveable electrode 14, having a piston part 48' which slidingly fits within a cylinder 50'.

In contrast to the previously described piston part 48 of torch 10, the piston part 48' is separate from the electrode 14 and may be fabricated from an insulating material. Furthermore, piston part 48' includes a piston skirt 66 which provides a relatively large piston to cylinder-wall contact area, guiding the electrode 14 and pr venting it from becoming skewed within the cylinder 50'. Additionally, the cylinder 50' is formed within a swirl ring 68 rather than at the lower end of the body 12 of the torch 10. The swirl ring 68 includes the gas swirl holes 32, leading tangentially from the annular space 28 into the plasma chamber 34. The swirl ring 68 may also be fabricated from an insulating material.

A major distinguishing feature of the hand-held torch 60 when compared to the torch 10 is that both electrical current flow and ionizable gas flow are initiated, in the proper sequence, by depressing a single start button 70.

The start button 70 includes a button stem 72 which passes through a contact plunger body 74 and an 0-ring 76, and finally engages a contact plunger 78. The contact plunger 78 has a plunger stem 80 which passes through a plunger return spring 82, a washer 84, and an insulator 86. The hole in the insulator 86 through which the plunger stem 80 passes has a diameter which is somewhat larger than the diameter of the plunger stem 80, so that there is an annular space between the plunger stem 80 and the insulator 86.

A plenum 22' is formed within a connector block 24' and is located immediately below the insulator 86. Within the plenum 22' is a gas inlet check ball 88 and a ball return spring 90. The ball return spring 90 urges the check ball 88 upward within the plenum 22 to rest against a seat area 92, blocking the hole at the bottom of the insulator 86.

The torch 60 is started by depressing the start button 70. This causes the button stem 72 to exert a downward force on the contact plunger 78, acting against the force of the return spring 82. The contact plunger 78, is at all times in electrical connection with a start button wire 94, through a circuit including the contact plunger body 74, the washer 84, and the return spring 82. In a similar manner, the gas inlet check ball 88 is at all times in electrical connection with the main current and gas tube 20, through a circuit including the connector block 24' and the ball return spring 90. The start button wire 94 connects the contact plunger body 74 to a remote starting current source (not shown).

When the start button 70 is depressed sufficiently so that the plunger stem 80 contacts the check ball 88, a circuit from the start button wire 94 to the main current and gas tube 20 is closed. This is the position shown in FIG. 2. The closing of this plunger to check ball starting circuit is sensed in the remote power supply (not shown), turning on the power supply and causing current on the order of 5 to 50 Amps to flow through the tube 20, the connector block 24', the plunger wire 36, the plunger 38, and into the electrode 14. As shown, at this point during the starting procedure, the electrode 14 is forced against the contact area 42 of the nozzle 16. Thus, current flows in the dead short mode of operation from the electrode 14 through the nozzle 16, into the cap 30, current ring 46', and pilot arc return lead 44.

By continuing to depr ss the start button 70 further, the check ball 88 is displaced downward from its normally seated position against seat area 92. This allows gas, under pressure from a remote gas source 51, connected to the main current and gas tube 20, to flow from the plenum 22' past the check ball 88, into the annular gap between the plunger stem 80 and the insulator 86, and through a passage 26' in the insulator 86, the connector block 24', and the body 12'. The gas generally follows arrows 52, flowing into the annular space 28, through the swirl holes 32, and fills the plasma chamber 34. In an alternate embodiment, some of the gas flow may be bypassed to cool the nozzle 16 through cooling holes 54, shown in phantom in FIG. 2.

In a manner similar to the operation of the torch 10, gas pressure exerts a force on the underside of the piston part 48', overcoming the force exerted by the electrode spring 40 and driving the electrode 14 upward within the cylinder 50', opening the orifice 18, and breaking electrical contact at area 42. To insure rapid movement of the electrode 14, a trapped gas bleed hole 96 allows any gas which flows past the plunger 38 and into a spring plenum 98 to bleed out of the plenum 98, preventing the gas from resisting the force exerted on the underside of piston part 48'. Thus, a pilot arc is generated between the electrode 14, serving as the cathode, and the nozzle 16, which serves as the anode. Gas flowing around the arc and through the nozzle orifice 18 forms a plasma jet, and the hand-held torch 60 may be operated in this nontransferred pilot arc mode.

The torch 60 may be converted to the transferred mode by bringing the torch, while operating in the pilot arc mode, near a workpiece held at anode potential, transferring the arc from the nozzle 16 to the workpiece. Once the arc is transferred, the pilot arc lead 44 could be interrupted, stopping current flow in the pilot arc circuit. The hand-held torch 60 will operate in either the pilot arc or transferred mode only as long as the start button 70 remains depressed.

When the start button 70 is released, the contact plunger 78 moves upward, allowing the check ball 88 to come into contact with and seal the seat area 92 stopping the gas flow and shutting down the plasma jet. As the plunger 78 continues to move upwardly, electrical contact between the plunger 78 and the check ball 88 is broken, and the open circuit is sensed by the remote power supply, stopping all current flow and shutting down the arc. The pressure in the plasma chamber 34 is simultaneously decreases, and the electrode 14 returns to its seated and normally closed position.

The ability of the electrode to be rapidly driven by the gas flow into its operating position after contact starting of the torch has been tested in the laboratory. Fig. 3 is a graph produced from an oscilliscope display of the results. Two traces are presented. An upper trace 100 is from the output of a pressure transducer and represents the pressure within the plasma chamber 34 as a function of time. A lower trace 102 is from the output of a motion or displacement transducer and represents the displacement of the electrode 14, also as a function of time. As can be clearly seen, the electrode 14 settles into its operating position in about 10 msec, well before the pressure in the plasma chamber has settled into its steady state value. The results of this experiment are typical for arc plasma torches, however the time required for the electrode to settle into its operating position will, of course, vary with factors such as the size of the piston part 48, 48', the force exerted by the electrode spring 40, and the steady state gas pressure supplied to the plasma chamber 34.

In the arc plasma torch contact starting system used to generate the data shown in Fig. 3, the piston part 48 had a diameter of approximately 7.62mm (0.300 inch), and the electrode 14 travel led upward approximately 2.54mm (0.1 inch) within the plasma chamber 34. The electrode spring 40 exerted a force of approximately 22.23 N (5lbs). The gas was supplied with a pressure of approximately 13.79 N/cm^2 (20 psi), and the nozzle orifice 18 had a diameter of only approximately 2.559mm (0.22 inch), insuring that the pressure in the chamber 34 remained high enough to keep the electrode 14 fixed against the end 56.

It is thus seen that the objects of this invention have been achieved and other advantageous results attained in that there has been disclosed a torch and method for starting the torch which does not require high frequency or high voltage discharges, which does not produce electro-magnetic interference, which does not require contact with a workpiece, which may be easily restarted, which automatically draws an arc, and which is simple and economical to construct, operate and repair.

While FIGS. 1 and 2 show arc plasma torches and components having substantially cylindrical shapes, it is to be understood that such structure is not intended as any limitation, as the present invention might be embodied in torches or components of different shapes.

Various modifications of the present invention will become apparent to those skilled in the art from the foregoing description and accompanying drawings. For example, a leaf-spring could replace the helical electrode spring or more generally the mechanical spring could be replaced by a fluid-type spring. Additionally, while the invention has been described as having an electrode which moves in response to pressure built up within a cylinder below a piston part, it would also be possible to have internal gas jets directed at vanes to move the electrode. Also, while the invention has been described with respect to a moveable cathode and a fixed anode, the cathode can be fixed while the gas pressure moves the anode structure, e.g. a nozzle extension piece. Further, it is possible, although perhaps more difficult to execute and control, to have both the cathode and the anode movably mounted with respect to one another in response to the applied gas pressure. Such modifications are intended to fall within the scope of the appended claims.

Claims

1. A method for starting to operate an arc plasma torch (10, 60) having a body (12, 12') with a plasma exit port (18) at one end and an anode (16) and a cathode (14) that are movable relative to one another within the torch body along a first direction, comprising:

   resiliently urging (40) the cathode (14) into electrical contact with the anode (16),

   providing a surface (48, 48') transverse to said first direction that is operatively coupled with movable one of said cathode (14) and anode (16),

   blocking said exit port (18) with said cathode (14) when said cathode (14) is in contact with said anode (16),

   providing a gas chamber (34) within said torch body,

   supplying a pressurized gas to the interior of the torch (10, 60) at said chamber,

   causing an electrical current to flow within the torch (10, 60) and from said cathode (14) to said anode (16),

   characterised in that, said gas chamber (34) is provided between said transverse surface (48) and said cathode (14) and said anode (16) that is sealed by said blocking, and

   at least some of said gas in said chamber (34) is directed to act on said transverse surface (48) to separate said anode (16) from said cathode (14) forcibly and against the force of said resilient urging (40) whereby an electric arc is generated between said anode (16) and said cathode (14) and whereby said exit port (18) is opened.

2. The method of claim 1 wherein said gas is an ionizable gas, and at least some of said gas is directed to flow around said arc and out of the torch (10, 60) when said anode (16) and said cathode (14) separate, forming a plasma jet.

3. The method of claim 2 wherein said anode (16) is a nozzle (16) having an orifice (18), and said plasma jet is directed to flow out of said orifice (18) when said nozzle (16) and said cathode (14) separate.

4. The method of claim 3 wherein said gas is substantially prevented from flowing out of said orifice (18) when said nozzle (16) and said cathode (14) are in contact.

5. The method of claim 3 further comprising:
providing a workpiece,
causing said workpiece to have an electrical potential substantially equal to the electrical potential of said nozzle (16), and
bringing the torch (10, 60) near said workpiece so that said plasma jet ionizes the gap between said nozzle (16) and said workpiece creating a current path from said nozzle (16) to said workpiece and transferring said arc to extend from said cathode (14) to said workpiece.

6. The method of claim 3 wherein at least some of said gas is directed to flow out of cooling holes (54) spaced from said nozzle orifice (18) and along the external surface of said nozzle (16).

7. The method of any one of the preceeding claims wherein a single control (70, 82, 88) is operated to initiate the flow of said current and the flow of said gas, whereby the flow of said gas follows the flow of said current.

8. An automatic arc plasma torch (10, 60) contact starting system, comprising:
a torch body (12, 12') having a plasma exit port (18) at one end,
an anode (16) supported on said body (12, 12'),
a cathode (14) supported within said body 12, 12'),
said anode (16) and cathode (14) being mounted for a mutual linear reciprocating movement along a first direction,
means (40, 38) mounted within said body for resiliently urging said cathode (14) along said first direction into electrical contact with said anode (16) and thereby closing said exit port (18),
means for causing an electrical current to flow between said cathode (14) and said anode (16),
characterised in that; means (20, 22, 28, 32) are provided for directing a gas to flow within the torch (10, 60) to separate said anode (16) from said cathode (14) forcibly, said directing means including a chamber (34), located within said body (12, 12') between said cathode (14) and said anode (16) that is closed to the exterior of said torch by said cathode (14) closing said exit port (18) when said cathode (14) and said anode (16) are placed into contact; and a surface is provided transverse to said first direction and coupled to the moveable one of said cathode (14) and anode (16) and against which said gas acts to separate said anode (16) from said cathode whereby an electrical arc is generated between said cathode (14) and said anode (16) and whereby said exit port (18) is opened.

9. The system of claim 8 wherein said cathode is an electrode (14) and said anode is a nozzle (16).

10. The system of claim 9 wherein said electrical contact urging means includes a coil spring (40).

11. The system of claim 9 further comprising a piston part (48, 48') formed integrally with said cathode (14) and wherein said chamber (34) slidingly receives said piston part (48), whereby gas accumulating within said chamber (34) exerts a force against said surface of said piston part (48, 48') opposite to the force exerted by said electrical contact urging means (40, 38) causing said cathode (14) to separate from said nozzle (16).

12. The system of claim 11 wherein said chamber (34) is on the opposite side of said piston part (48, 48') from said electrical contact urging means (40, 38).

13. The system of any one of claims 8-12 wherein said gas directing means directs at least some of said gas to flow around said arc.

14. The system of claim 13 wherein said anode is a nozzle (16) having an orifice (18) and said gas flowing around said arc and out of said orifice (18) forms a plasma jet.

15. The system of claim 14 wherein said gas directing means substantially prevents said gas from flowing out of said nozzle orifice (18) when said nozzle (16) and said cathode (14) are in contact.

16. The system of claim 15 further comprising cooling holes (54) spaced from said nozzle orifice (18), and means for directing at least

some of said gas to flow out of said cooling holes (54) and along the external surface of said nozzle (16).

17. The system of any one of claims 13-16 wherein said gas directing means (32) directs said gas to swirl around said arc.

18. The system of any one of claims 8-17 further comprising means (70, 82, 88) for initiating said current flow followed by said gas flow.

19. The system of claim 18 wherein said initiating means includes a start button (70).

20. The system of claim 19 wherein said initiating means includes a starting circuit (78, 94, 74, 84, 82) which is closed when said start button (70) is depressed.

21. The system of claim 20 further comprising means for sensing when said starting circuit is closed, whereby said electrical current flowing means co-operates with said sensing means to start flowing current from said cathode (14) to said anode (16) when said starting circuit is closed.

22. The system of claim 20 wherein said initiating means includes means (88, 92) for opening a gas flow passage (26') when said start button (70) is depressed beyond the point where said starting circuit is closed, whereby said passage opening means co-operates with said gas flow directing means to start directing said gas to flow when said gas flow passage is opened.

23. The system of claim 22 wherein said passage opening means includes:

a plenum (22') having an opening,

a check ball (88) within said plenum sized to block said opening (92), and

means (90) for urging said check ball to block said plenem opening, whereby said check ball (88) is displaced from blocking said opening when said start button (70) is depressed beyond the point where said starting circuit is closed.

Patentansprüche

1. Verfahren zum Starten des Betriebs eines Lichtbogen-Plasma- Brenners (10, 60), der ein Gehäuse (12, 12') mit einer Plasma- Austritts-Öffnung (18) an einem Ende und eine Anode (16) und eine Kathode (14) aufweist, die in Bezug zueinander innerhalb des Brennergehäuses entlang einer ersten Richtung bewegbar sind, bei dem

- die Kathode (14) durch federndes Hinbewegen (40) in elektrischen Kontakt mit der Anode (16) gebracht wird,
- eine Fläche (48, 48') quer zur ersten Richtung angeordnet wird, die operativ mit der Bewegbaren der beiden Kathode (14) oder Anode (16) verbunden ist,
- die Austrittsöffnung (18) durch die Kathode (14) verschlossen wird, wenn die Kathode (14) in Kontakt mit der Anode (16) ist, eine Gaskammer (34) innerhalb des Brennergehäuses vorgesehen wird,
- unter Druck stehendes Gas in das Innere des Brenners (10,60) in die Kammer eingeleitet wird,
- das Fließen eines elektrischen Stroms innerhalb des Brenners (10,60) von der Kathode (14) zu der Anode (16) bewirkt wird,

  dadurch gekennzeichnet, daß die Gaskammer (34) zwischen der quer gelegenen Fläche (48) und der Kathode (14) und der Anode (16) angeordnet und durch den Verschluß abgedichtet wird, und

  daß zumindest ein Teil des in der Kammer (34) befindlichen Gases an die Querfläche (48) geleitet wird, um die Anode (16) von der Kathode (14) gegen die Kraft des federnden Antriebs (40) zwangsweise zu Trennen, wodurch ein elektrischer Lichtbogen zwischen der Anode (16) und der Kathode (14) erzeugt wird und wodurch die Austrittsöffnung (18) geöffnet wird.

2. Verfahren nach Anspruch 2, bei dem das Gas ein ionisierbares Gas ist, und zumindest ein Teil des Gases zum Umströmen des Lichtbogens und Austreten aus dem Brenner (10, 60) geführt wird, wenn sich die Anode (16) und die Kathode (14) trennen, wobei ein Plasmastrahl gebildet wird.

3. Verfahren nach Anspruch 2, bei dem die Anode (16) eine Dose (16) mit einer Öffnung (18) ist, und der Plasmastrahl zum Austreten durch die Öffnung (18) geführt wird, wenn die Düse (16) und die Kathode (14) sich trennen.

4. Verfahren nach Anspruch 3, bei dem das Gas im wesentlichen daran gehindert wird durch die Öffnung (18) auszutreten, wenn die Düse (16) und die Kathode (14) in Kontakt sind.

5. Verfahren nach Anspruch 3, bei dem ferner

- ein Werkstück vorgesehen wird,

- ein elektrisches Potential dem Werkstück gegeben wird, das im wesentlichen gleich dem elektrischen Potential der Düse (16) ist, und
- der Brenner (10, 60) in die Nähe des Werkstücks gebracht wird, so daß der Plasmastrahl den Spalt zwischen der Düse (16) und dem Werkstück ionisiert, einen Strompfad zwischen der Düse (16) und dem Werkstück bildet und den Lichtbogen überträgt, so daß dieser sich von der Kathode (14) zum Werkstück erstreckt.

6. Verfahren nach Anspruch 3, bei dem zumindest ein Teil des Gases durch Kühlungslöcher (54), welche mit Abstand zu der Düsenöffnung (18) angeordnet sind, und entlang der Außenoberfläche der Düse (16) zum Ausströmen geführt wird.

7. Verfahren nach irgend einen der vorangehenden Ansprüche, bei dem eine einzige Steuerung (70, 82, 88) zum Starten des Stromflußes und der Gasströmung betätigt wird, wobei die Gasströmung dem Stromfluß nachfolgt.

8. Automatisches Kontaktzündsystem eines Lichtbogen-Plasma-Brenners (10, 60), mit

- einem Brennergehäuse (12,12'), das eine Plasma-Austrittsöffnung (18) an einem Ende auftweist,
- einer an dem Gehäuse (12, 12') angebrachten Anode (16),
- einer in dem Gehäuse (12, 12') angebrachten Kathode (14), wobei die Anode (16) und die Kathode (14) zur Ausführung einer gemeinsamen, hin- und hergehenden, linearen Bewegung entlang einer ersten Richtung montiert sind,
- innerhalb des Gehäuses angebrachte Mittel (40, 38) zum federnden Bewegen der Kathode (14) entlang der ersten Richtung, um diese in elektrischen Kontakt mit der Anode (16) zu bringen und hierbei die Austrittsöffnung (18) zu verschließen,
- Mittel die bewirken, daß ein elektrischer Strom zwischen der Kathode (14) und der Anode (16) fließt,

dadurch gekennzeichnet, daß Mittel (20, 22, 28, 32) zum Führen eines Gases vorgesehen sind, damit das Gas innerhalb des Brenners (10, 60) strömt, um die Anode (16) zwangsweise von der Kathode (14) zu trennen, wobei die Führungsmittel eine Kammer (34) beinhalten, die innerhalb des Gehäuses (12, 12') zwischen der Kathode (14) und der Anode (16) angeordnet und zum äußeren des Brenners hin durch die die Austrittsöffnung (18) verschließende Kathode (14) verschlossen ist, wenn die Kathode (14) und die Anode (16) in Kontakt miteinander gebracht sind; und daß eine Fläche quer zur ersten Richtung vorgesehen ist, die mit dem Bewegbaren der beiden Elemente, Kathode (14) oder Anode (16), verbunden ist und auf die das Gas einwirkt, um die Anode (16) von der Kathode (14) zu trennen, wodurch ein elektrischer Lichtbogen zwischen der Anode (16) und der Kathode (14) erzeugt wird, und wodurch die Austrittsöffnung (18) geöffnet wird.

9. System nach Anspruch 8, bei dem die Kathode eine Elektrode (14) und die Anode eine Düse (16) ist.

10. System nach Anspruch 9, bei dem die den elektrischen Kontakt bewirkenden Mittel eine Schraubfeder (40) beinhalten.

11. System nach Anspruch 9, welches ferner einen Kolbenteil (48, 48') aufweist, der mit der Kathode (14) integral ausgebildet ist, und bei dem die Kammer (34) den Kolbenteil (48, 48') gleitbar aufnimmt, wodurch sich innerhalb der Kammer (34) ansammelndes Gas eine Kraft gegen die Fläche des Kolbenteils (48, 48') ausübt, die der von den elektrischen Kontakt erzeugenden Mittel (40, 38) erzeugten Kraft entgegen gerichtet ist, und eine Trennung der Kathode (14) von der Anode (16) bewirkt.

12. System nach Anspruch 11, bei dem die Kammer (34) auf der den elektrischen Kontakt bewirkenden Mitteln (40,38) entgegengesetzten Seite liegt.

13. System nach irgend einem der Ansprüche 8-12, bei dem die Gasführungsmittel zumindest einen Teil des Gases führen damit dieses um den Lichtbogen herum strömt.

14. System nach Anspruch 13, bei dem die Anode eine Düse (16) mit einer Öffnung (18) ist und das um den Lichtbogen und aus der Öffnung (18) strömende Gas einen Plasmastrahl bildet.

15. System nach Anspruch 14, bei dein die Gasführungsmittel im wesentlichen ein Ausströmen des Gases durch die Düsenöffnung (18) verhindern, wenn die Düse (16) und die Elektrode (14) in Kontakt miteinander sind.

16. System nach Anspruch 15, welches ferner Kühlungslöcher (54) aufweist, die mit Abstand zu der Düsenöffnung (18) angeordnet sind, und Mittel aufweist, die zumindest einen Teil des Gases führen, um durch die Kühlungslöcher (54) aus- und entlang der äußeren Oberfläche der Düse (16) zu strömen.

17. System nach irgend einem der Ansprüche 13-16, bei dem die Gasführungsmittel (32) das Gas führen damit dieses um den Lichtbogen herum wirbelt.

18. System nach irgend einem der Ansprüche 8-17, welches ferner Mittel (70, 82, 88) zum Starten des Stromflußes und nachfolgend der Gasströmung aufweist.

19. System nach Anspruch 18, bei dem die Startmittel einen Startknopf (70) beinhalten.

20. System nach Anspruch 19, bei dem die Startmittel einen Zündstromkreis (78, 94, 74, 84, 82) beinhalten, der geschlossen wird, wenn der Startknopf (70) betätigt ist.

21. System nach Anspruch 20, welches ferner Mittel aufweist, die registrieren wann der Zündstromkreis geschlossen ist, wodurch die elektrischen Stromflußmittel mit den Registriermitteln zusammenwirken um einen Stromfluß von der Kathode (14) zu der Anode (16) zu bewirken, wenn der Zündstromkreis geschlossen ist.

22. System nach Anspruch 20, bei dem die Startmittel Mittel (88, 92) zum Öffnen eines Gasströmungskanals (26') aufweisen, wenn der Startknopf (70) über den Punkt hinaus betätigt ist, an dem der Zündstromkreis geschlossen ist, wodurch die Kanalöffnungsmittel mit den Gasführungsmitteln zusammenwirken, um Gas zum Strömen zu bringen, wenn der Gasströmungskanal geöffnet ist.

23. System nach Anspruch 22, bei dem die Kanalöffnungsmittel

- einen Hohlraum (22') mit einer Öffnung,
- eine Prüfkugel (88) innerhalb des Hohlraums, die zum Verschließen der Öffnung (92) bemessen ist, und
- Mittel (90) beinhalten, die die Prüfkugel (88) zum Verschließen der Hohlraumöffnung bewegen, wodurch die Prüfkugel (88) von der die Öffnung verschließenden Stellung verfahren wird, wenn der Startknopf (70) über den Punkt hinaus betätigt ist, an dem der Zündstromkreis geschlossen ist.

Revendications

1. Méthode pour commencer à utiliser un chalumeau à plasma d'arc (10, 60) comprenant un corps (12, 12') avec un orifice de sortie du plasma (18) à une extrémité, une anode (16) et une cathode (14) pouvant être déplacées l'une par rapport à l'autre dans le corps du chalumeau le long d'une première direction comprenant:

un rapprochement, de façon résiliante (40), de la cathode (14), pour obtenir un contact électrique avec l'anode (16), l'établissement d'une surface (48, 48') transversale par rapport à ladite première direction, liée de façon opérationnelle avec celle des deux qui est mobile parmis la cathode (14) et l'anode (16),

un bloquage dudit orifice de sortie (18) avec ladite cathode (14) lorsque ladite cathode (14) est en contact avec ladite anode (16),

l'établissement d'une chambre à gaz (34) dans ledit corps du chalumeau pour fournir un gaz pressurisé à ladite chambre à l'intérieur du chalumeau (10, 60),

l'établissement d'un courant électrique pour circuler dans le chalumeau (10, 60) de ladite cathode (14) vers ladite anode (16),

caractérisé en ce que ladite chambre à gaz (34) est disposée entre ladite surface transversale (48), ladite cathode (14) et ladite anode (16) qui est scellée par ledit bloquage, et au moins une partie dudit gaz dans ladite chambre (43) est dirigé pour agir sur ladite surface transversale (48) afin de séparer de force ladite anode (16) de ladite cathode (14) en agissant contre la force dudit rapprochement (40), où un arc électrique est généré entre ladite anode (16) et ladite cathode (14) et où ledit orifice de sortie (18) est ouvert.

2. Méthode selon la revendication 1, dans laquelle ledit gaz est un gaz pouvant être ionisé et au moins une partie dudit gaz est dirigée autour dudit arc et à l'extérieur du chamuleau (10, 60) lorsque ladite anode (16) et ladite cathode (14) se séparent, formant un jet de plasma.

3. Méthode selon la revendication 2, dans laquelle ladite anode (16) est une buse (16) comportant un orifice (18) et ledit jet de plasma est dirigé pour s'écouler dudit orifice (18) lorsque ladite buse (16) et ladite cathode (14) se séparent.

4. Méthode selon la revendication 3, dans laquelle ledit gaz est pratiquement empêché de

s'écouler dudit orifice (18) lorsque ladite buse (16) et ladite cathode (14) sont en contact.

5. Méthode selon la revendication 3, comprenant également;

   l'établissement d'une pièce de travail faisant que celle-ci a un potentiel électrique pratiquement égal au potentiel électrique de ladite buse (16), un rapprochement du chalumeau (10, 60) près de ladite pièce de travail de sorte que ledit jet de plasma ionise l'espace entre ladite buse (16) et ladite pièce, créant un passage de courant de ladite buse (16) vers ladite pièce et transférant ledit arc pour s'étendre de ladite cathode (14) à ladite pièce.

6. Méthode selon la revendication 3, dans laquelle au moins une partie dudit gaz est dirigée pour s'écouler des trous de refroidissement (54) séparés dudit orifice de la buse (18) et le long de la surface externe de ladite buse (16).

7. Méthode selon l'une des revendication précédentes, dans laquelle un contrôle simple (70, 82, 88) est utilisé pour initialiser l'écoulement dudit courant et l'écoulement dudit gaz et où l'écoulement dudit gaz suit l'écoulement dudit courant.

8. Système de mise en marche par contact d'un chalumeau à plasma d'arc automatique, comprenant:

   un corps de chalumeau (12, 12') comportant un orifice de sortie du plasma (18) à une extrémité,

   une anode (16), disposée sur ledit corps (12, 12'),

   une cathode (14) disposée dans ledit corps (12, 12'), ladite anode (16) et ladite cathode (14) étant disposées pour un mouvement alternatif linéaire mutuel le long d'une première direction,

   des moyens (40, 38) disposés dans ledit corps, servant à rapprocher de façon résiliante ladite cathode (14) le long de ladite première direction pour obtenir un contact électrique avec ladite anode (16) et fermant ainsi ledit orifice de sortie (18),

   des moyens pour générer un courant électrique circulant entre ladite cathode (14) et ladite anode (16),

   caractérisé en ce que les moyens (20, 22, 28, 32) sont fournis pour diriger un gaz afin qu'il s'écoule dans le chalumeau (10, 60) pour séparer de force ladite anode (16) de ladite cathode (14), lesdits moyens de direction comportant une chambre (34), disposée dans ledit corps (12, 12') entre ladite cathode (14) et ladite anode (16), qui est fermée à l'extérieur dudit chalumeau par ladite cathode (14) qui ferme ledit orifice de sortie (18) lorsque ladite cathode (14) et ladite anode (16) sont placées en contact; une surface transversale à ladite première direction est établie et liée à celle des deux que l'on peut déplacer parmis ladite cathode (14) et l'anode (16), et contre laquelle ledit gaz agit pour séparer ladite anode (16) de ladite cathode, où un arc électrique est généré entre ladite cathode (14) et ladite anode (16) et où ledit orifice de sortie (18) est ouvert.

9. Système selon la revendication 8, dans lequel ladite cathode est une électrode (14) et ladite anode est une buse (16).

10. Système selon la revendication 9, dans lequel ledit moyen de rapprochement des contacts électriques comprend un ressort en bobine (40).

11. Système selon la revendication 9, comprenant également une partie de piston (48, 48') formée de façon intégrale avec ladite cathode (14), et dans lequel ladite chambre (34) reçoit par glissement ladite partie de piston (48), où le gaz s'acculumant dans ladite chambre (34) exerce une force contre ladite surface de ladite partie de piston (48, 48') opposée à la force exercée par lesdites moyens de rapprochement des contacts électriques (40, 38) entraînant la séparation de ladite cathode (14) de ladite buse (16).

12. Système selon la revendication 1, dans lequel ladite chambre (38) est sur le côté opposé de ladite partie de piston (48, 48'), à partir desdits moyens de rapprochement de contact électrique (40, 38).

13. Système selon l'une des revendications 8 à 12, dans lequel lesdits moyens de direction des gaz dirigent au moins une partie desdits gaz pour s'écouler autour dudit arc.

14. Système selon la revendication 13, dans lequel ladite anode est une buse (16), comportant un orifice (18) et lesdits gaz s'écoulant autour dudit arc ainsi qu'à l'extérieur dudit orifice (18) forment un jet de plasma.

15. Système selon la revendication 14, dans lequel ledit moyen de direction des gaz évite pratiquement auxdits gaz de s'écouler dudit orifice de la buse (18), lorsque ladite buse (16) et ladite cathode (14) sont en contact.

16. Système selon la revendication 15, comprenant également des trous de refroidissement (54) séparés de l'orifice de la buse (18), et des moyens pour diriger au moins une partie dudit gaz pour s'écouler à l'extérieur desdits trous de refroidissement (54) et le long de la surface extérieure de ladite buse (16).

17. Système selon l'une des revendications 13 à 16, dans lequel ledit moyen de direction des gaz (32) dirige ledit gaz pour le faire tourbillonner autour dudit arc.

18. Système selon l'une des revendications 8 à 17, comprenant également des moyens (72, 82, 88) pour initialiser ledit écoulement de courant suivi par ledit écoulement de gaz.

19. Système selon la revendication 18, dans lequel ledit moyen d'initialisation comprend un bouton de mise en route (70).

20. Système selon la revendication 19, dans lequel ledit moyen d'initialisation comprend un circuit de mise en route (78, 94, 74, 84, 82) qui est fermé lorsque ledit bouton de mise en route (70) est abaissé.

21. Système selon la revendication 20, comprenant également un moyen pour détecter lorsque ledit circuit de mise en route est fermé, où ledit moyen d'écoulement du courant électrique coopère avec ledit moyen de détection pour débuter l'écoulement du courant de ladite cathode (14) vers ladite anode (16) lorsque ledit circuit de mise en marche est fermé.

22. Système selon la revendication 20, dans lequel ledit moyen d'initialisation comprend des moyens (88, 92) pour ouvrir un passage d'écoulement de gaz (26') lorsque ledit bouton d'une mise en marche (70) est pressé au-delà du point où ledit circuit de mise en marche est fermé, où ledit moyen d'ouverture du passage coopère avec ledit moyen de direction d'écoulement du gaz pour commencer à diriger ledit gaz afin d'avoir un écoulement lorsque ledit passage d'écoulement du gaz est ouvert.

23. Système selon la revendication 22, dans lequel ledit moyen d'ouverture du passage comprend un collecteur (22') comprenant une ouverture, une bille de contrôle (88) dans ledit collecteur, dimensionné pour bloquer ladite ouverture (92), et

des moyens (90) pour diriger ladite bille de contrôle pour bloquer ladite ouverture du collecteur où ladite bille de contrôle est déplacée de la position de bloquage de ladite ouverture lorsque ledit bouton de mise en marche (70) est pressé au-delà du point où ledit circuit de mise en rout est fermé.

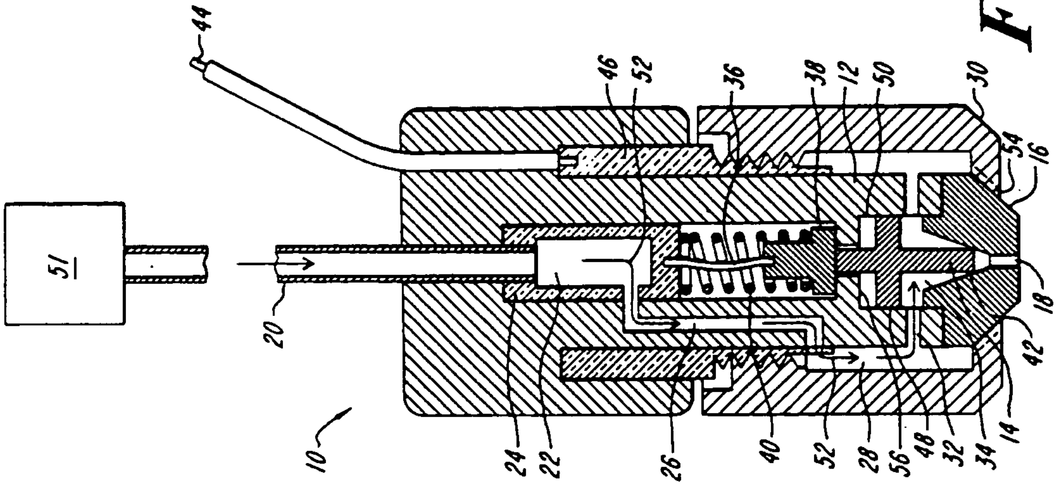
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FIG. 1

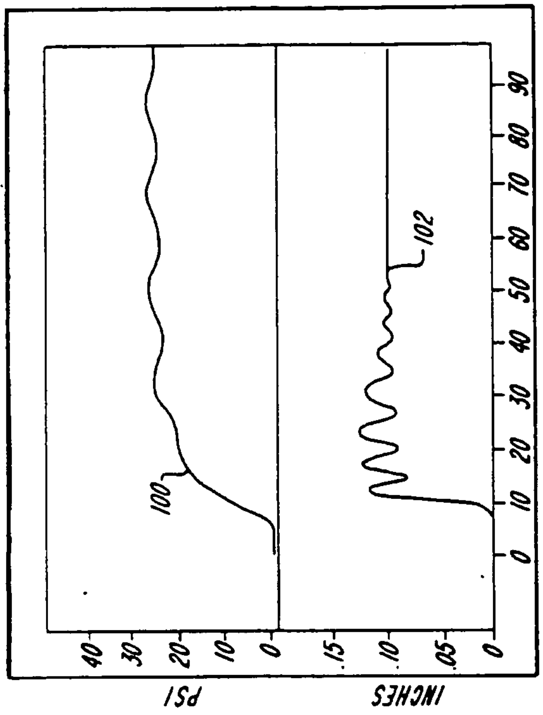
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FIG. 3

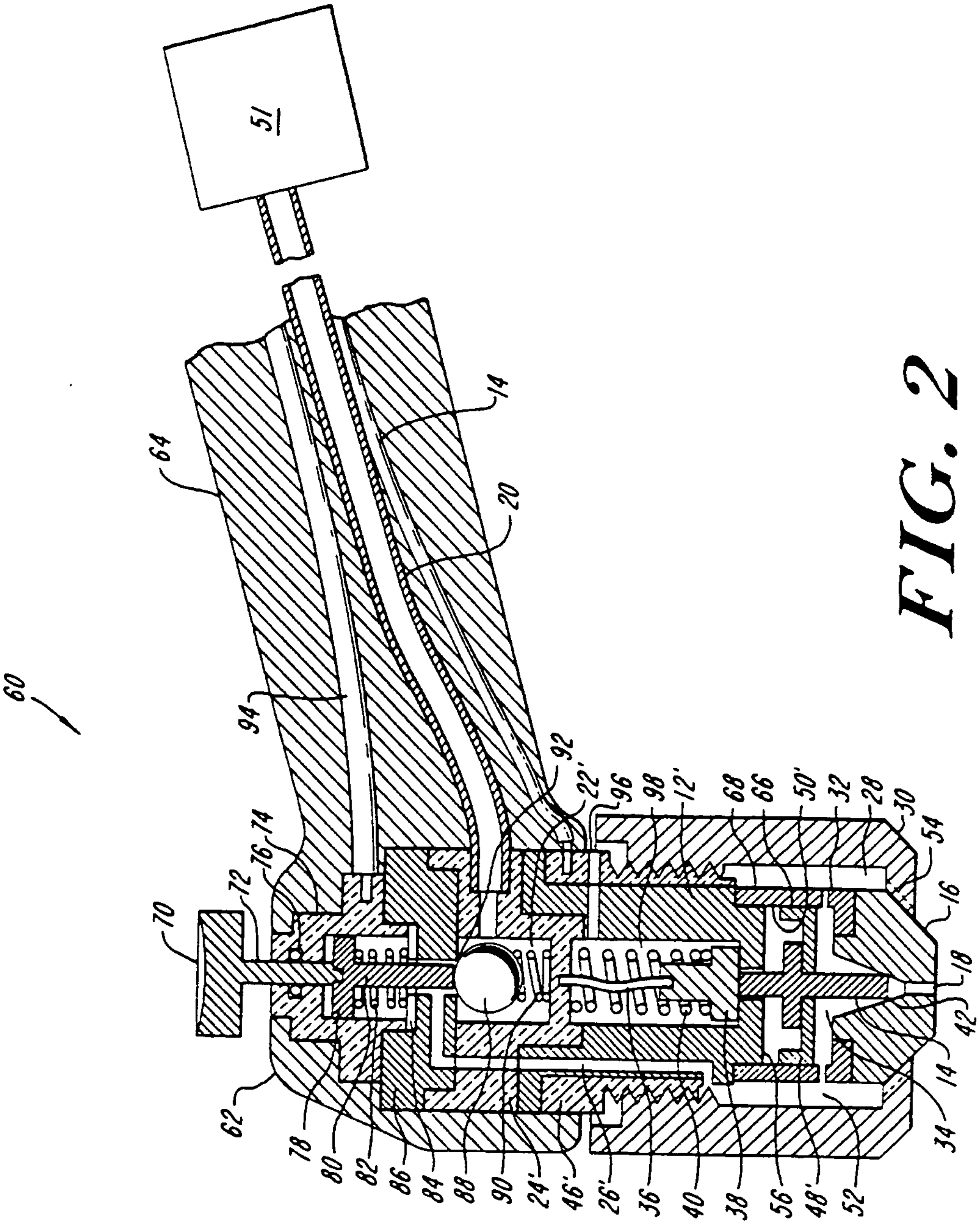

FIG. 2